Developing and Evaluating Intelligent Eco-Drive Applications

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Project Overview

This project developed a vehicle predictive eco-cruise control system that minimizes vehicle fuel consumption levels utilizing roadway topographic information. The predictive eco-cruise control system consists of three components: a fuel consumption module, a power-train module, and an optimization algorithm.

The vehicle predictive eco-cruise control system generates an optimal control plan using roadway grade information obtained from a high resolution digital map to control the vehicle speed within a preset speed window in a fuel-saving manner. The performance of the system was tested by simulating a vehicle trip on a section of Interstate 81 in the state of Virginia. The results demonstrate fuel savings up to 15 percent with execution times within real-time.

Eco-Cruise Control System

The operation of the vehicle predictive eco-cruise control system conceptually follows four events. First, future topographic information is fed to the system from a navigational mapping system. Second, the user sets a target cruise speed and a speed range (or speed window) for the vehicle to operate within. Next, the system generates an optimal plan for throttle, braking levels, and gear selections over a predefined distance. The system then updates these procedures over the entire trip. The predictive eco-cruise control system consists of three building blocks: a powertrain module, a fuel consumption module, and an optimization module. These modules are closely connected with each other so that the system can simulate the vehicle operations under the given topographic information and characteristics of a testing vehicle, estimate the fuel consumption rates based on the vehicle operating conditions, and find an optimal control plan that minimizes the vehicle fuel consumption while satisfying the preset vehicle speed range.

Demonstration of the System

The predictive eco-cruise system was simulated on a 45 km section of Interstate 81 from Roanoke to Blacksburg in the state of Virginia. Since the study section includes multiple uphill 16 and downhill segments, with grades ranging from -4 percent to +4 percent, it is appropriate to demonstrate the performance of the system. Specifically, it is possible to examine the behavior of the system on the uphill and downhill sections regarding speed, throttle, braking level, and gear selection. The simulation will show how the system optimizes fuel consumption rates when uphill sections are anticipated in a predictive manner and how the system maximizes the utilization of gravitational energy.

Conclusions

The study demonstrated that the developed predictive eco-cruise control system can generate an optimal vehicle control plan in real time. In addition, the study demonstrated that the heuristic search algorithm finds the optimum plan more quickly with a gap in the objective function of less than 1 percent when compared to the shortest path algorithm. Specifically, testing of the system showed that the largest fuel savings are achieved along hilly terrain sections. In addition, the study demonstrated that the penalty for the deviation from the target speed is used to control the degree of the deviation. For future research efforts, there is a need to quantify the potential benefits of using the predictive eco-cruise system in a systematic manner. It would be especially insightful to compare the performance of the predictive eco-cruise control system with that of the conventional cruise control system.